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لجنة ارتباط قطر

Introduction to Piping Design

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Introduction to Piping Design

- Ahmad Haidar Akila
- Started His Career as Mechanical Design Engineer in Jopetrol.
- Working as Sr. Piping Design Engineer at Black Cat Consulting and Engineering Services (BCCES).
- Holds PE in Mechanical Systems and Materials -NCEES # 14-942-32
- Holds PMP, PMP # 1478283.

What is the pipe

- As per Merriam Webster dictionary , the pipe is a long tube or hollow body for conducting a liquid, gas, or finely divided solid.
- Technically : The pipe Is a **beam** , which acts as pressure vessel and transfer fluids.

Piping System

- The piping system is group of pipes , fittings and flanges which connects equipment and pipelines inside stations

Piping System

- Piping systems includes :

1. The pipes , fittings and flanges .
2. Valves.
3. Gaskets and bolts
4. Special Piping Components (Insulation Gaskets, Special Valves, Filters and strainers, Corrosion Protection Fittings, etc).
5. Pipe Supports

Difference Between Piping pipelines

Piping	Pipelines
Transfer fluids between equipment's and from the pipeline boundaries to inside stations	Transfer fluid between stations
Design Factor of Safety is higher than pipelines	Design Factor of Safety is lower than piping
Has complex shapes	Straight shapes
Mostly above ground	Can be above ground or under ground.
Less allowable operating displacement (typically between 25mm to 75mm)	Higher allowable operating displacement
Design Temperature can be as high as 650 °C	Maximum Design Temperature is 232°C for the gas pipeline, and 120°C for the liquid pipeline

International Standards of Design

- ASME B31.3 : Process Piping
- This piping is typically found in petroleum refineries, chemical and pharmaceutical plants, and many other process plants and terminals. It has a high-pressure section. It recognizes different degrees of fluids safety concerns and imposes different rules on each. It has a nonmetallic section. It is generally considered the most broadly applicable code

International Standards of Design

- ASME B31.3 : Process Piping

A. Normal Service
B. Category D : IA and FW
C. Category M: Lethal Service
D. High Pressure service
E. High temperature service
F. High purity service

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ASME B31.3 Fluid Service

fluid service: a general term concerning the application of a piping system, considering the combination of fluid properties, operating conditions, and other factors that establish the basis for design of the piping system. See Appendix M.

(a) Category D Fluid Service: a fluid service in which all of the following apply:

(1) the fluid handled is nonflammable, nontoxic, and not damaging to human tissues as defined in para. 300.2

(2) the design gage pressure does not exceed 1 035 kPa (150 psi)

(3) the design temperature is not greater than 186°C (366°F)

(4) the fluid temperature caused by anything other than atmospheric conditions is not less than –29°C (–20°F)

(b) Category M Fluid Service: a fluid service in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to persons on breathing or bodily contact, even when prompt restorative measures are taken.

ASME B31.3 Fluid Service

(d) High Pressure Fluid Service: a fluid service for which the owner specifies the use of Chapter IX for piping design and construction; see also para. K300.

(e) High Purity Fluid Service: a fluid service that requires alternative methods of fabrication, inspection, examination, and testing not covered elsewhere in the Code, with the intent to produce a controlled level of cleanness. The term thus applies to piping systems defined for other purposes as high purity, ultra high purity, hygienic, or aseptic.

(f) Normal Fluid Service: a fluid service pertaining to most piping covered by this Code, i.e., not subject to the rules for Category D, Category M, Elevated Temperature, High Pressure, or High Purity Fluid Service.

International Standards of Design

- ASME B31.1 : Power Piping

This code is the original code and was a direct development out of the *Boiler* and subsequent codes. A boiler needs pipe, both internally and externally. The internal pipe would come under the rules of ASME Section I and the external piping would come under ASME B31.1. This piping is generally found in electric power generating stations. It is typically transporting steam or water under elevated temperatures and pressures. It may be used in other heating and steam uses.

Other International Standards of Design

- ASME B31.5 :Refrigeration piping and heat transfer components.
- ASME B31.8 :Gas transmission and distribution piping systems.
- ASME B31.9: Building services piping

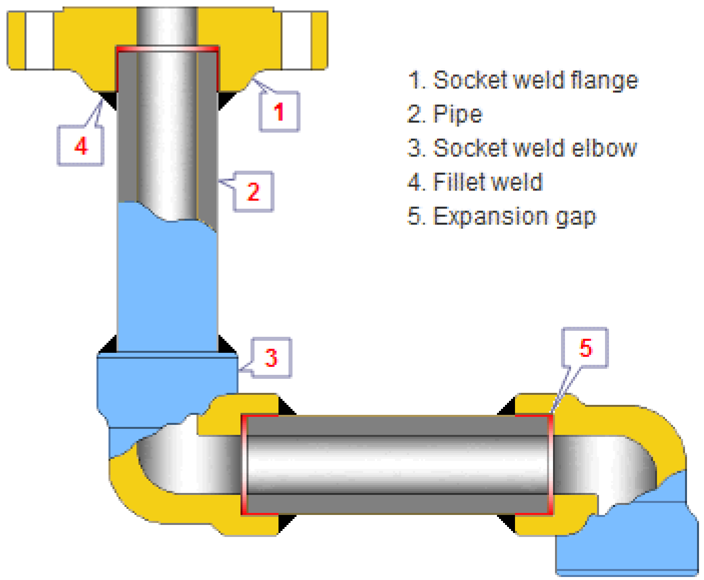
Piping Discipline and Process Discipline Relation

- Process Discipline provides all the process calculations (**Pipe sizing** , hydraulic Calculations, etc).
- Process Discipline Provides the P&ID's.
- Piping Disciplines provides the piping material classes in order for the process to select the appropriate material and thickness for the piping lines.
- Process Discipline provides the piping with the design conditions of the piping systems (Design Pressure, Design Temperature , fluid services).

Piping System Configuration

Welded Configuration .

A. Socket Welded.



For Further reading visit:
http://www.wermac.org/fittings/socket_weld_general.html

Piping System Configuration

Welded Configuration .

A. Butt Welded /

- Contributes of Most of the piping configurations .
- Zero Leakage .
- Welding Strength is higher than pipe material strength.

Piping System Configuration

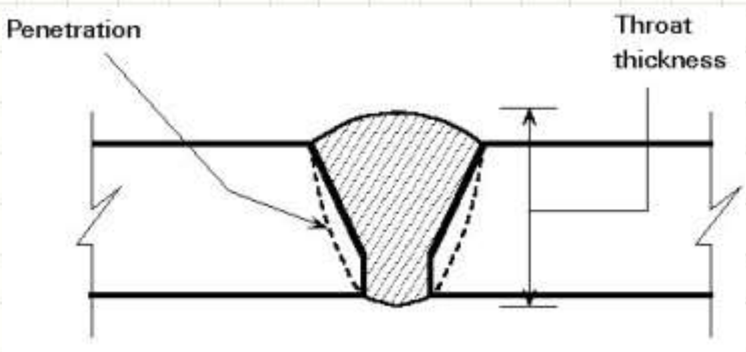
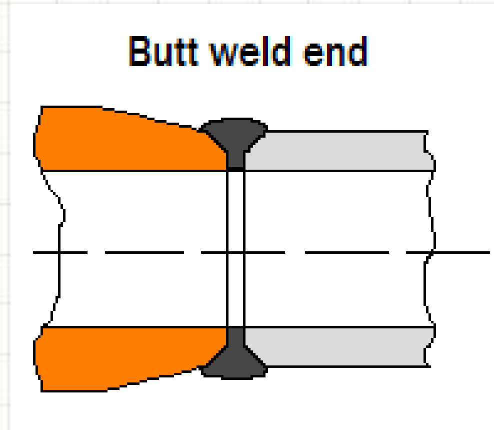
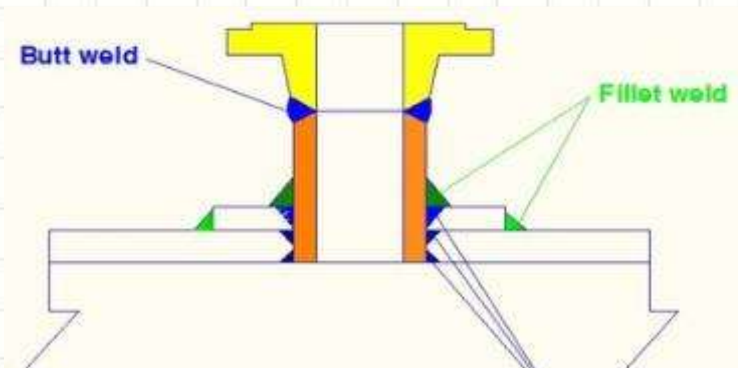


Figure 1 Butt weld with full penetration





Groove Weld

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Piping System Configuration

Fig. 328.4.2 Typical Butt Weld End Preparation

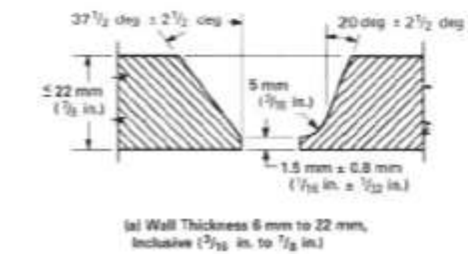
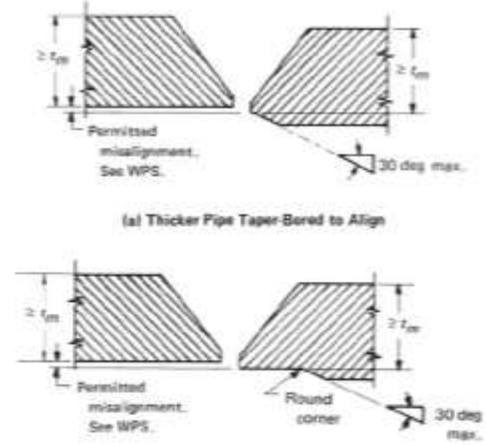
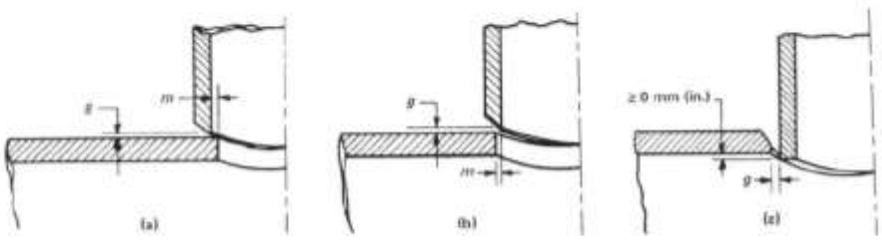


Fig. 328.4.3 Trimming and Permitted Misalignment



ASME B31.3-2012

Fig. 328.4.4 Preparation for Branch Connections

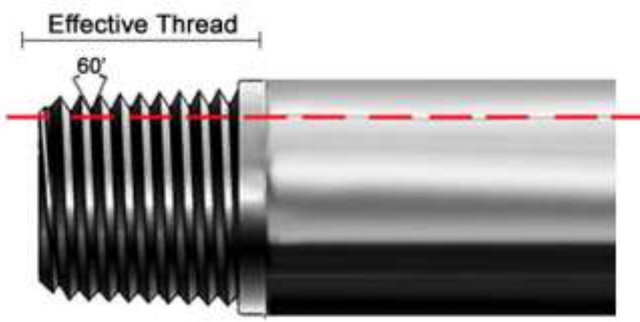


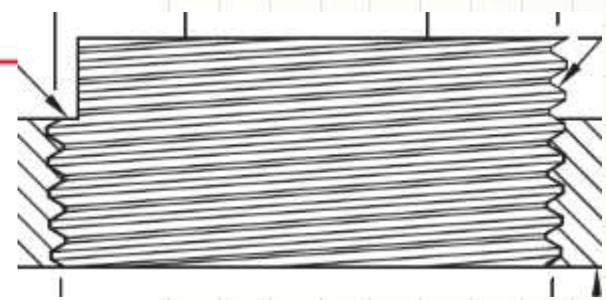
g = root gap per welding specification
m = the lesser of 3.2 mm (1/8 in.) or 0.5 T_b

Piping System Configuration

1. Threaded Configuration .

- Used for the utilities (IA and utility water) .
- End Connections are Threaded (Male or Female).
- NPT (National Pipe Threads) is the common types of threads – ASME B1.20.1.
- Sealant like Teflon or Loctite® shall be used.





Other Configurations

- Groove End Piping

Piping Components

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Pipe

- The main component of the piping system.
- Sizes can be prescribed in :

A. NPS (Nominal Pipe Size –Inch System).
B. DN (Diameter Nominal – mm System)

- For the NPS system , 2 dimensional standards can be used :

A. ASME B36.10 (CS dimensions)
B. ASME B36.19 (SS dimensions)

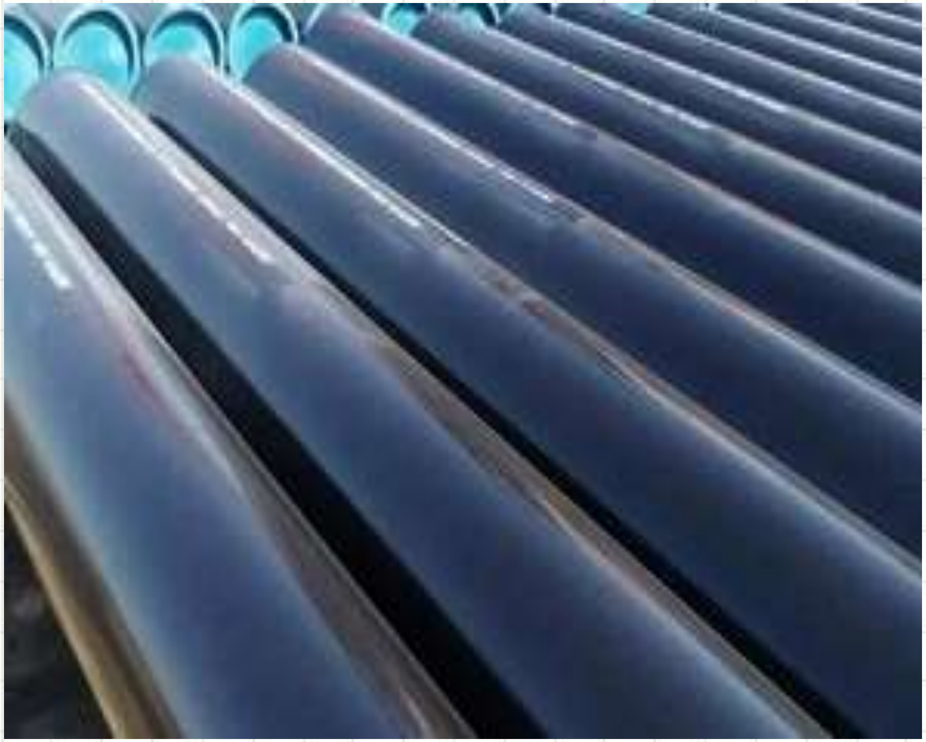
- For NPS thickness described in Schedule (Schedule 10, 20, 30,40 , STD, XS,XXS ,etc).
- In NPS system, Outside Diameter of the pipe is higher than the NPS*25.4 for small sizes up to 12”, for the 14” and above , Pipe OD is equal to NPS *25.4.
- Can be supplied in Single Length (6 Mtr), Random Single Length (4,88-6,86 Mtr), Double Length (12 Mtr) and Random Double Length (11-12 Mtr) and some times in higher lengths

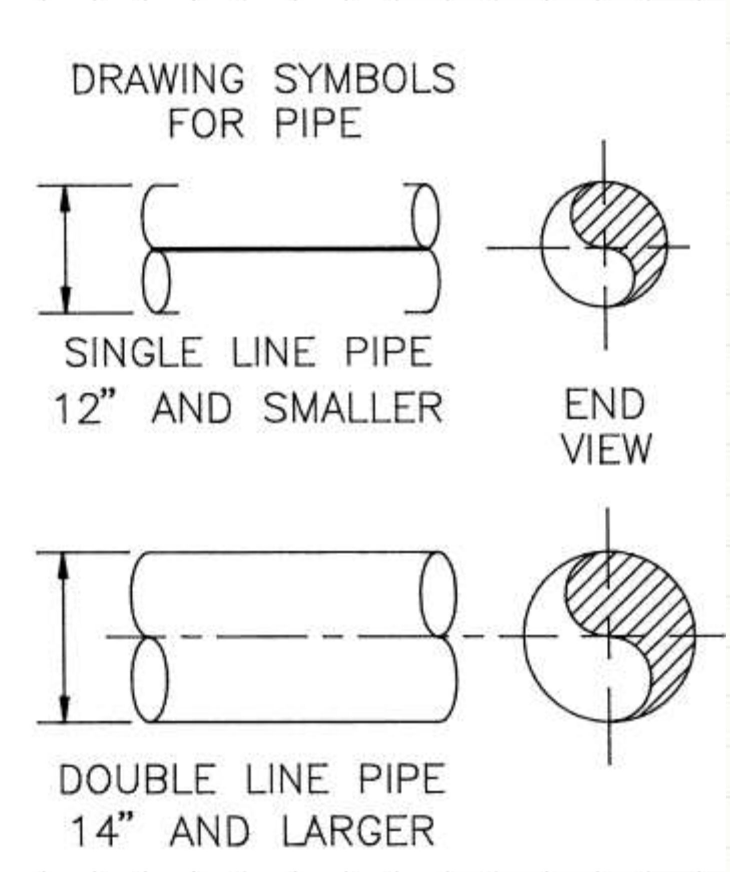
Pipe

Table 12 — Tolerances for random length pipe

Random length designation m (ft)	Minimum length m (ft)	Minimum average length for each order item m (ft)	Maximum length m (ft)
Threaded-and-coupled pipe			
6 (20)	4,88 (16.0)	5,33 (17.5)	6,86 (22.5)
9 (30)	4,11 (13.5)	8,00 (26.2)	10,29 (33.8)
12 (40)	6,71 (22.0)	10,67 (35.0)	13,72 (45.0)
Plain-end pipe			
6 (20)	2,74 (9.0)	5,33 (17.5)	6,86 (22.5)
9 (30)	4,11 (13.5)	8,00 (26.2)	10,29 (33.8)
12 (40)	4,27 (14.0)	10,67 (35.0)	13,72 (45.0)
15 (50)	5,33 (17.5)	13,35 (43.8)	16,76 (55.0)
18 (60)	6,40 (21.0)	16,00 (52.5)	19,81 (65.0)
24 (80)	8,53 (28.0)	21,34 (70.0)	25,91 (85.0)

Pipes

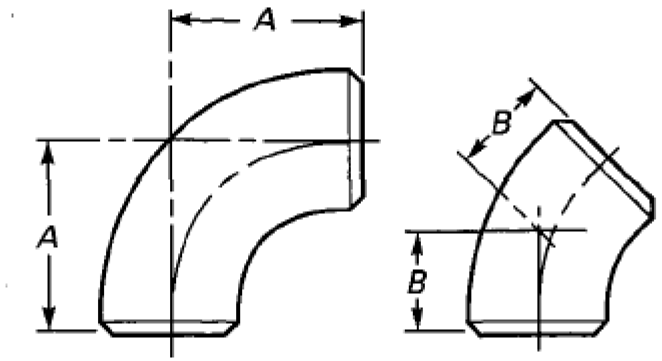



DRAWING SYMBOLS FOR PIPE
SINGLE LINE PIPE 12" AND SMALLER
END VIEW
DOUBLE LINE PIPE 14" AND LARGER

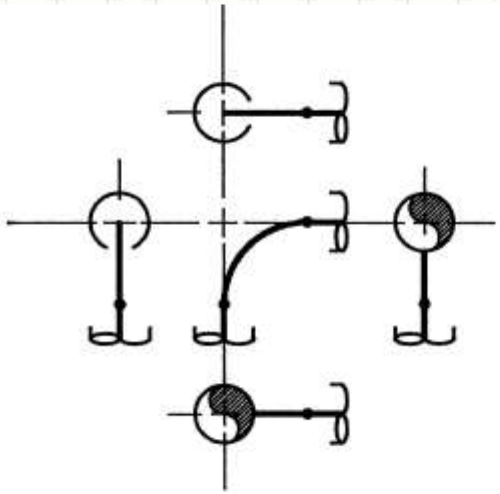
Elbows

- Used for any change in direction .
- Long Radius (1.5D) or Short Radius.
- Dimensional Standards (ASME B16.9).
- Sizes and thickness designation same as pipe.

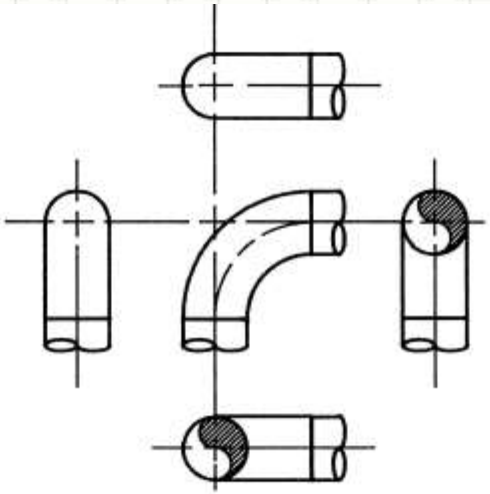
Elbows



Elbows Draughting



Single line: 12″ and smaller



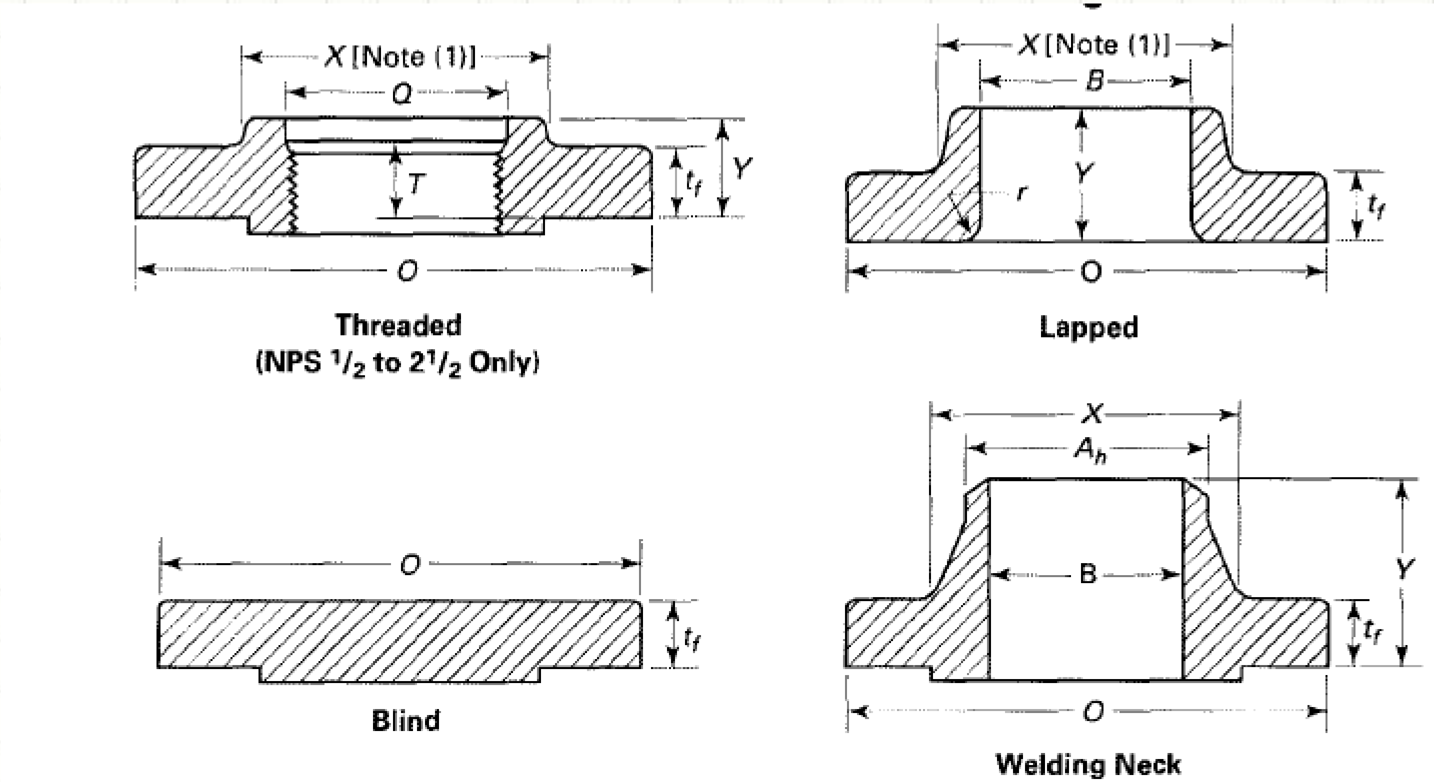
Double line: 14″ and larger

Flanges

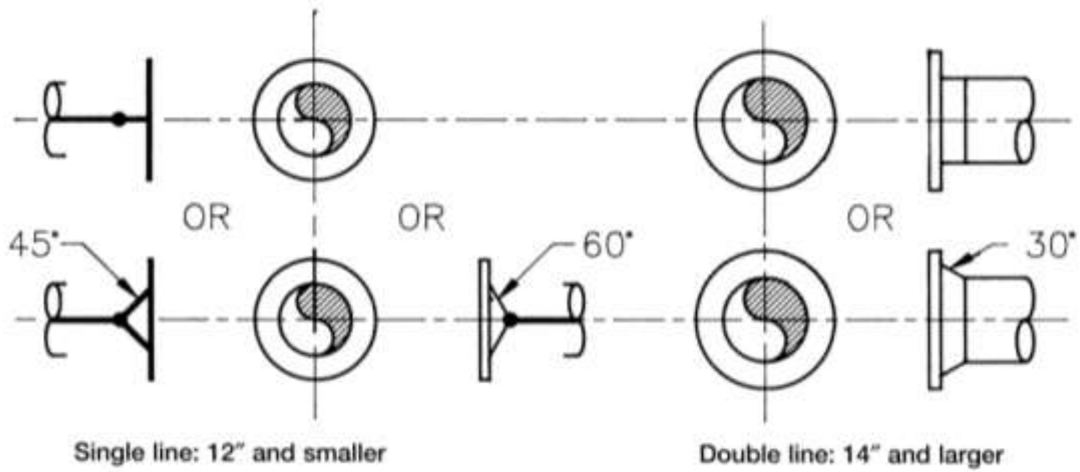
- Used in the places in which the pipe shall be easily dismantled for Maintenance.
- Used to attach piping system to equipment's.
- Source of leakage in the piping system.
- Pressure rating is defined by the symbol # ,which means PSI.
- Pressure rating is defined by the Manufacturing Standard (Not by pipe thickness).
- ASME Pressure Rating :150#,300#,400#,600#,900#,1500# and 2500#.
- API Pressure Rating : 2000#, 3000#, 5000#, 10000#, 15000#, 20000#
- Dimensional and Pressure Rating Standard is ASME B16.5 .ASME B16.47,API 6A).

Flanges Ends

- Weld neck
- Threaded
- Socket weld
- Slip-on
- lap-joint
- Blind


X [Note (1)]
Q
T
t_f
Y
O
Threaded
(NPS 1/2 to 2 1/2 Only)
X [Note (1)]
B
r
Y
t_f
O
Lapped
O
t_f
Blind
X
A_h
B
Y
t_f
O
Welding Neck

Flanges Ends



ıg symbols.

Figure 4-14. Slip-on flange drawing symbols.

Figure 4-20. Single-line socket-weld drawing symbol.

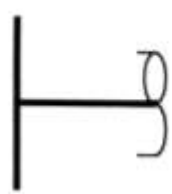


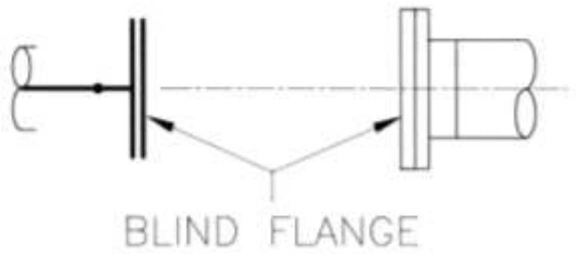
Figure 4-18. Single-line threaded flange drawing symbol.

Flange Facing

- Raised Face (RF)
- Flat Face (FF)
- Ring Type Joint (RTJ)

Flanges Ends

Figure 4-23. Blind flange.

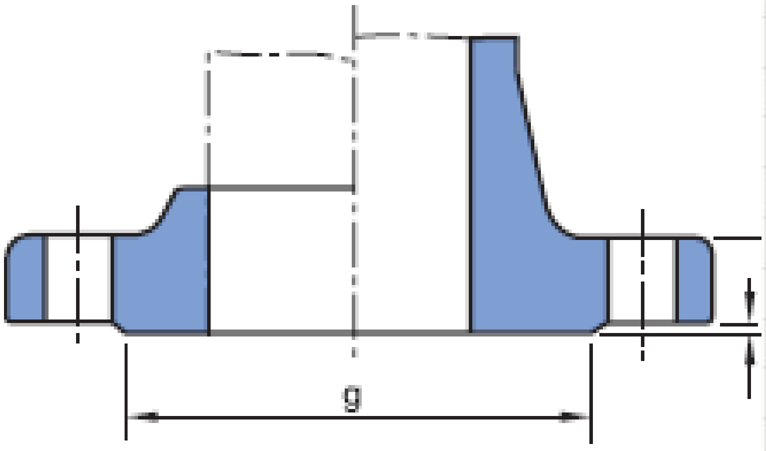


Single line: 12" and smaller Double line: 14" and larger
Figure 4-24. Blind flange drawing symbols.

Flange Facing

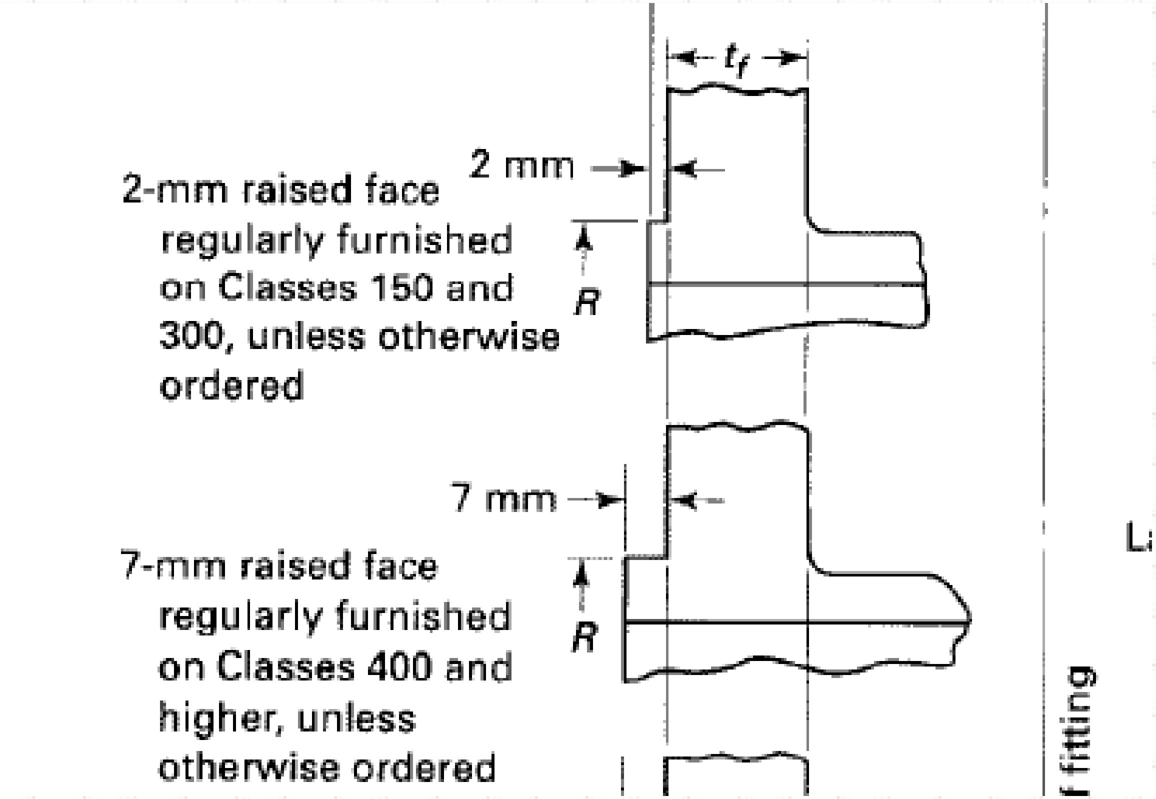
- Raised Face
- Used for optimum gasket seating.
- RF thickness is 2 mm (150#-300#)
- RF thickness is 7 mm (600#-1500#)
- Used in General up to 900#.

Flange Facing



RAISED FACE (LARGE)

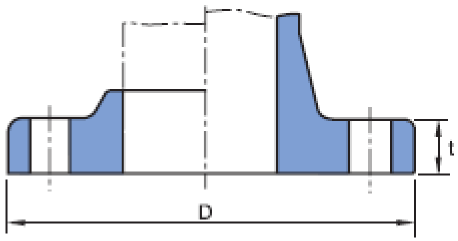
Raised Face


t_f
2 mm
2-mm raised face regularly furnished on Classes 150 and 300, unless otherwise ordered
R
7 mm
7-mm raised face regularly furnished on Classes 400 and higher, unless otherwise ordered
R
f fitting

Flat Face

- Used for low pressure .
- Used when mating between CS flanges and Cast Iron is required or when CS flanges and Plastic flanges mating is required.

Flat Face



FLAT FACE

Ring Type Joint

- Used in Higher Pressure application 900# and above

Ring Type Joint

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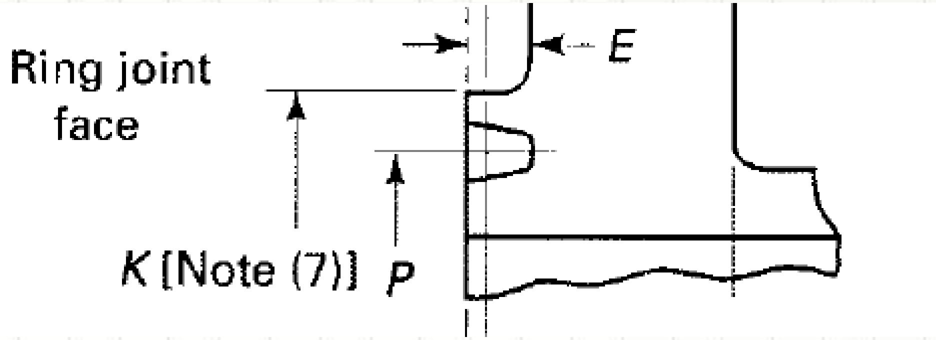

Caps

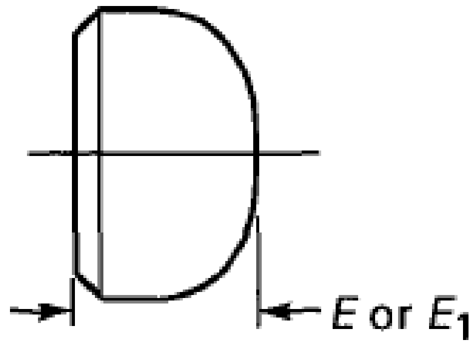

Table 11 Dimensions of Caps

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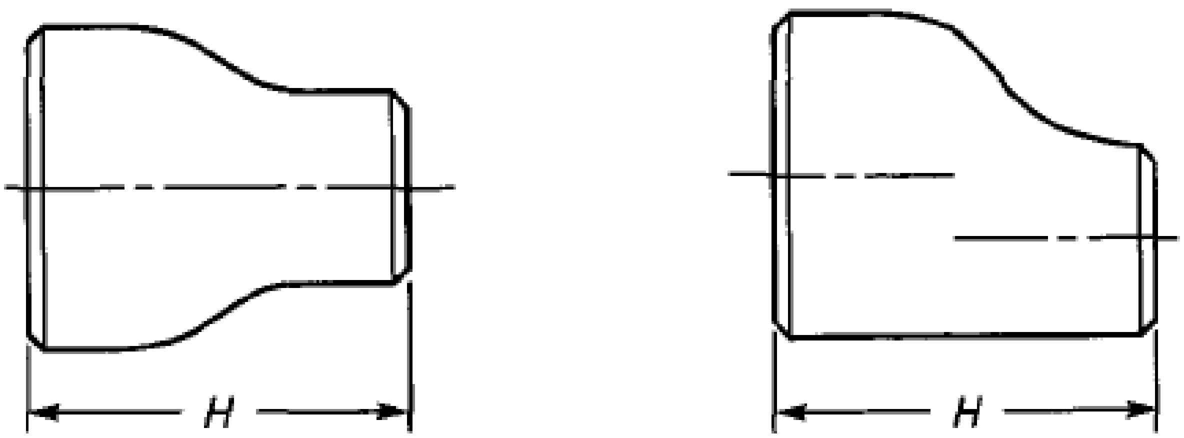
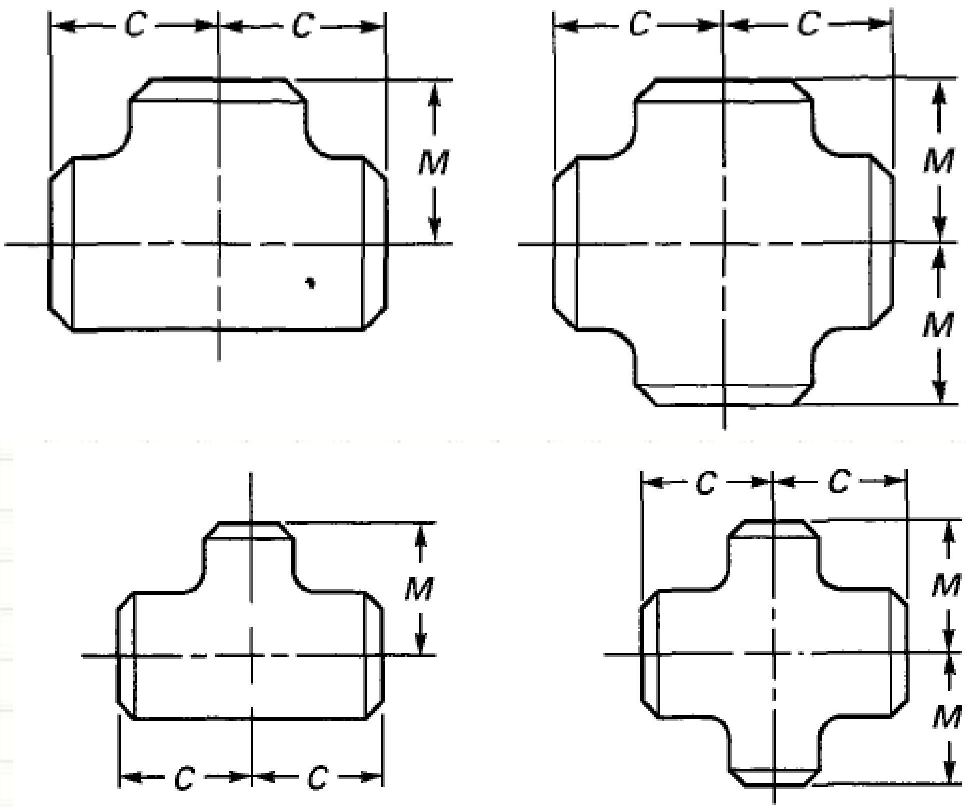
Reducers



Tees and Crosses



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Gaskets

- Spiral Wound
- Flat Ring
- Ring Gasket

Spiral Wound

- The most common used gasket component.
- Can seal under heavy operating conditions .
- Manufactured as per ASME B16.20
- Easy installation due the robust shape of the gasket.
- Relatively higher torque value is required for gasket seating.
- Filler ring can be graphite, PTFE , Vermiculite, Phlogopite (magnesium mica), Flexible graphite, Ceramic.
- Major component : Spiral Wound with the filler material (Sealing Element), Inner ring and Outer(Centering) ring.

Spiral Wound

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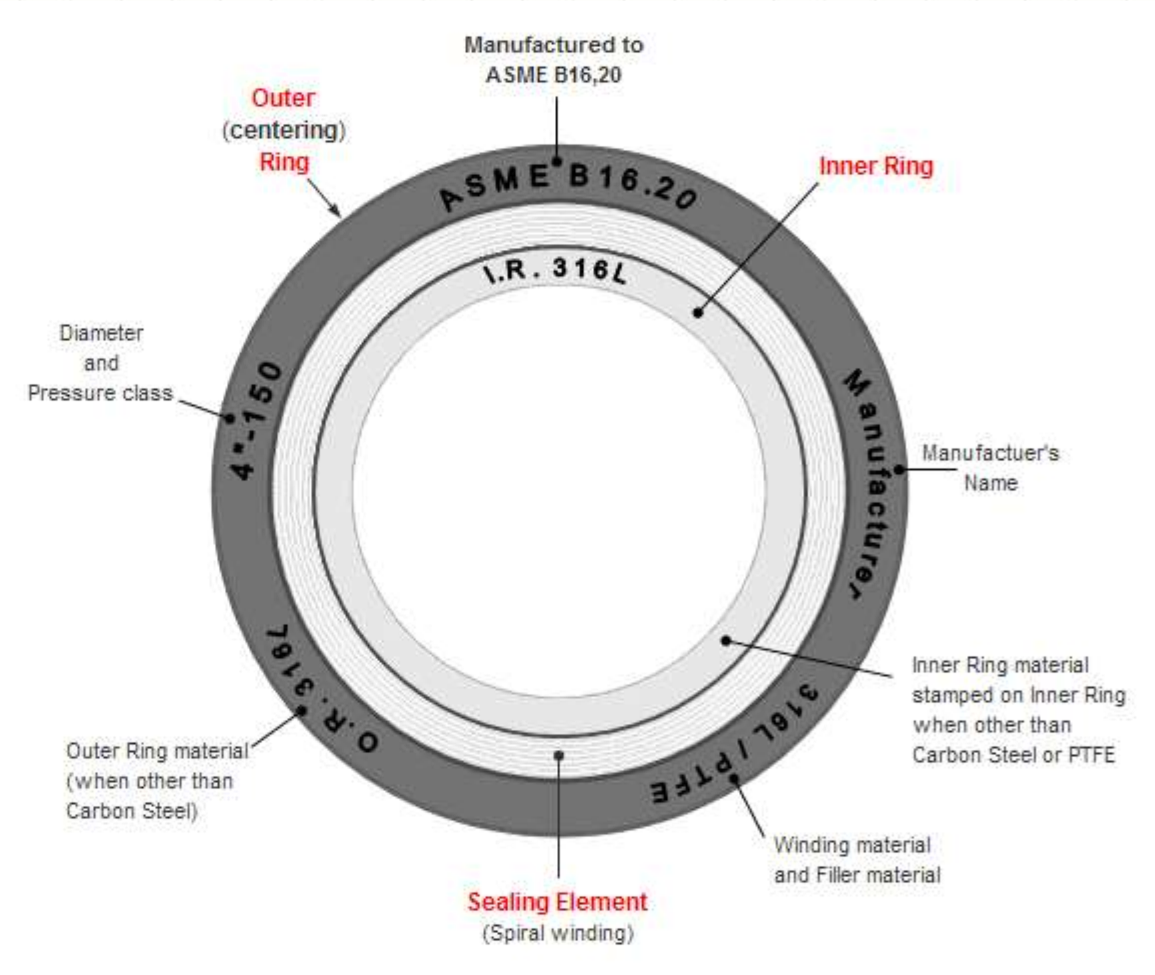


Flat Ring Gasket

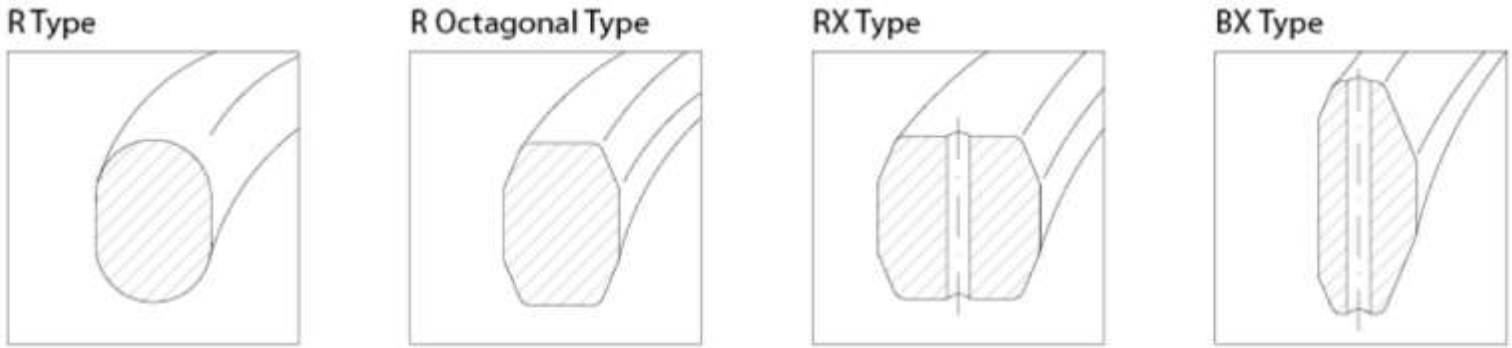
- Used usually for lower pressure rating 150#-300# and lower temperature.
- Less torqueing value in compare with the same rating of SW gaskets.
- Manufactured from elastomer material.
- Less cost.

Flat Ring Gasket

Ring Gaskets

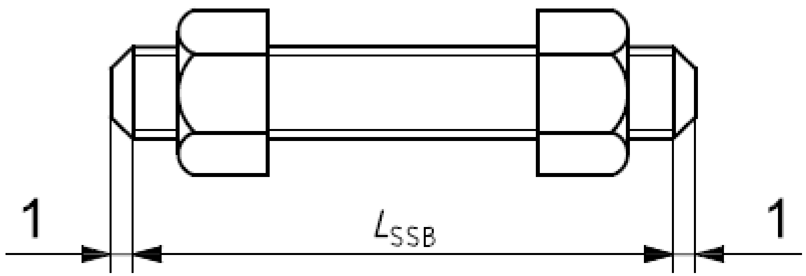
- Used for high pressure rating 900# and above.
- Manufactured from metals such as soft iron.
- Oval shape, Octagonal shape .
- Can be also pressure energized type (RX/BX)

Ring Gaskets



Stud Bolts

- Bolts are used to connect the flange joints.
- Bolt length shall be calculated to satisfy the client requirements such as exposed threads.



c) Stud bolt with nuts

Valves

- Gate Valves
- Ball Valves
- Globe Valves
- Butterfly valves
- Check Valves : Piston , Swing type , Single plate, Dual Plate.
- Choke Valves .
- Plug Valves
- Safety Relief valves.

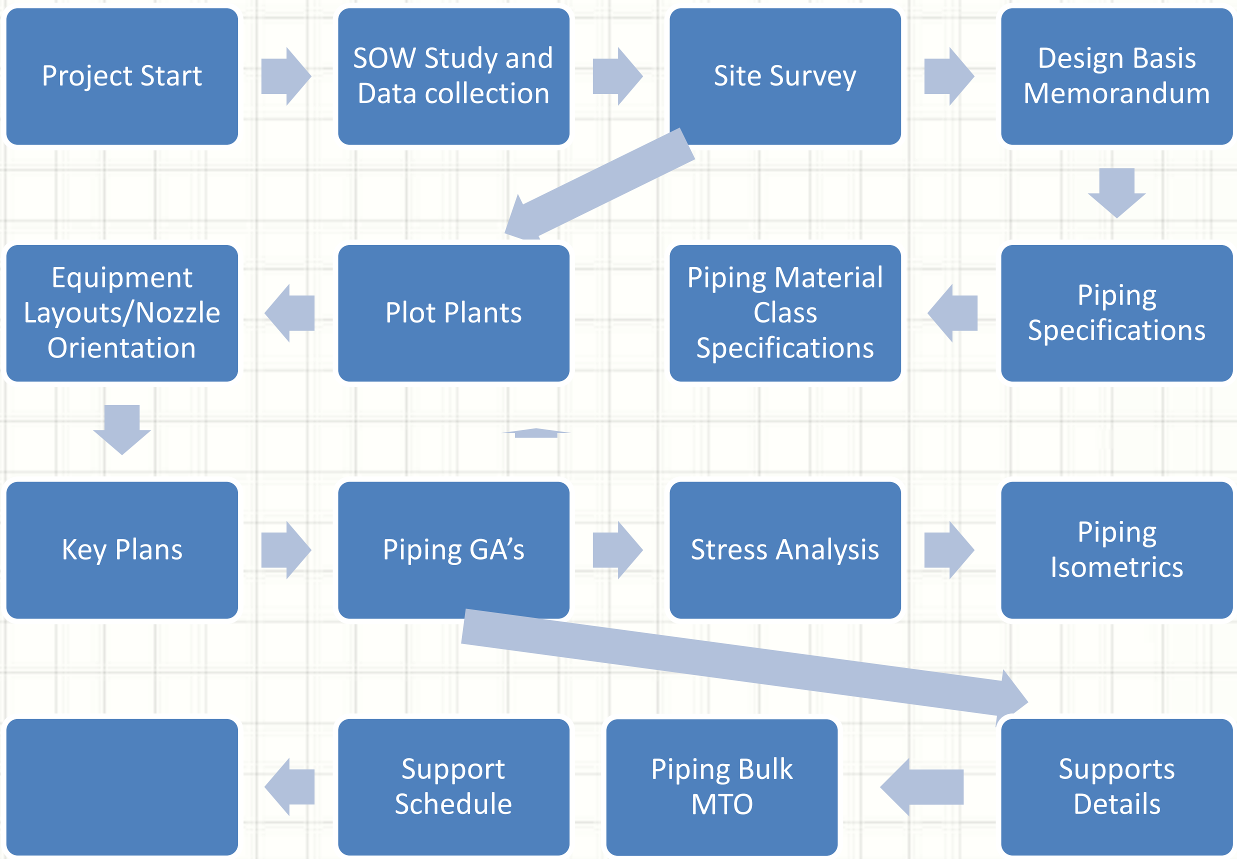
Valves uses

Table 12.2.4 Applications of isolating valve types

Valve type	General applications	Actuation	Remarks
Globe valve	Shut-off/regulation of liquid/gas flow. Steam and condensate applications.	Usually manual, but may be: - Electric - Manual - Hydraulic - Pneumatic	Usually applied to higher pressure or high volume systems, due to cost. Less suitable for viscous or contaminated fluids.
Piston valve	Used fully open or fully closed for on/off regulation on steam, gas and other fluid services. Typically used on fluids that cause excessive seat wear.	Usually manual, but may be: - Electric - Manual - Hydraulic	Usually used where the valve body is to be permanently installed and maintenance needs to be minimised.
Gate valve	Normally used fully open or fully closed for on/off regulation on water, oil, gas, steam and other fluid services.	Usually manual, but may be: - Electric - Manual - Hydraulic	Not recommended as a throttling valve. Solid wedge gate is free from chatter and jamming. Parallel slide valve used in steam systems.
Butterfly valve	Shut-off and regulation in larger pipelines in waterworks, process industries, HPI, power generation.	Handwheel Electric motor Pneumatic actuator Hydraulic actuator Air motor	Relatively simple construction. Can be produced in very large sizes. Eccentric design essential for steam systems. Typically used on liquid systems.
Ball valve	Wide range of applications in all sizes, including HPI. Steam and condensate applications.	Handwheel Electric motor Pneumatic actuator Hydraulic actuator	Can handle all fluid types. Limited maximum pressure.

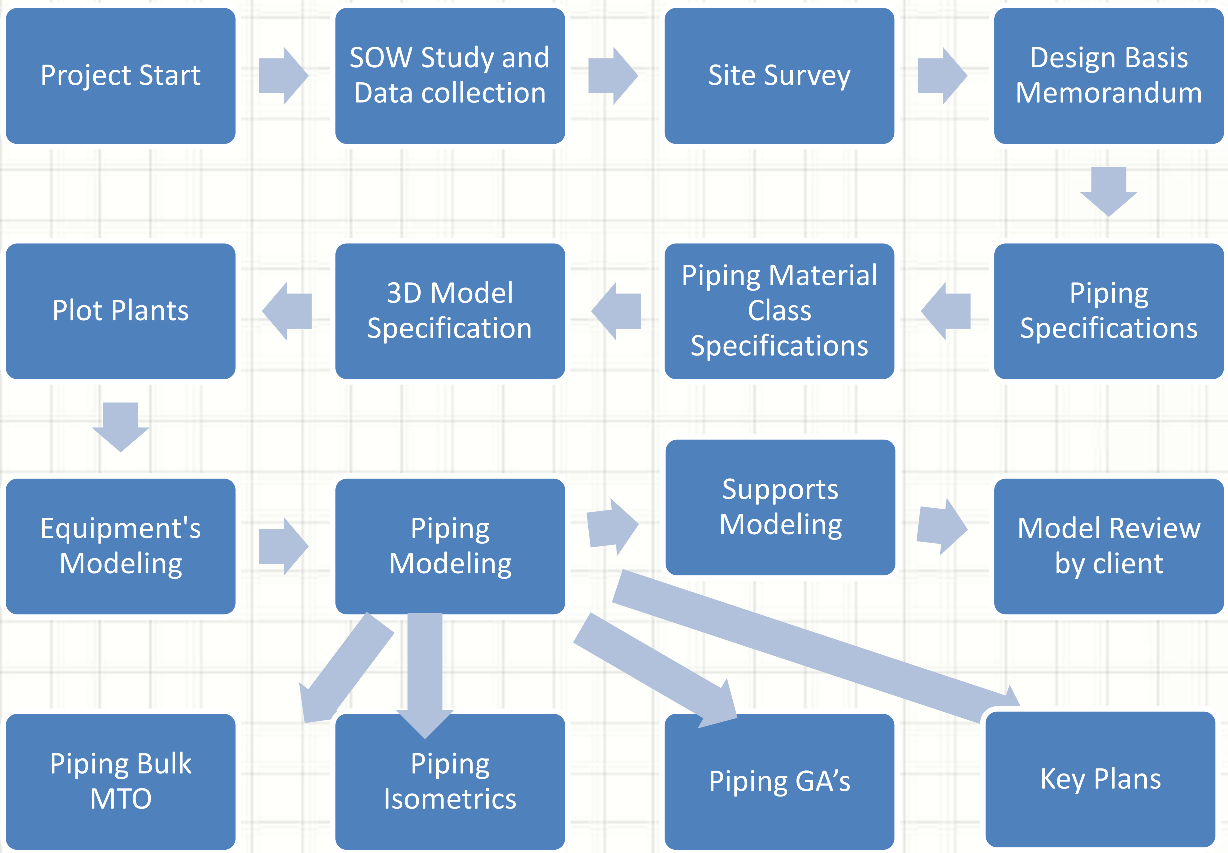
Stages of piping Design from Start to the project End

- Manual Draughting



Stages of piping Design from Start to the project End

- 3d Modeling



Design Basis

- This document includes the following :

A. The scope of the design .
B. The Design approach (Which documents will be submitted , the international codes and standards to be used, client standards to be used , the material selection criteria, the design assumptions ,etc).

- This documents defines how the design shall be done, and shall be submitted and approved in the beginning of the project to avoid rework.

Piping Material Class Specifications

- Include grouping of pipes , fitting, flanges, gaskets, etc which can be used for certain pressure ranges, temperature ranges and services ranges.
- Usually includes single nominal material designation (Eg. CS A106 Gr.B) .
- Has coding system which explains the class uses : Example:
- 150-C-1 : 150 : Flange Ratings .

  C: CS steel

  1: Corrosion Allowance .

Plot Plans

- Scale between 1:200 up to 1:2000.
- Defines the scope of the project .
- The main purpose of this drawing is the area allocation and the overall plant design.
- Area allocation includes required areas and coordinates.
- Plot plans show the location of all the buildings, equipment, pipe racks, and other items of importance in the unit.
- True north and plant north are also shown.
- Includes the Road/Access outlines
- Shows sometimes the coordinates of the major equipment.
- Sometimes the plant Coordinate System is defined on the plot plan

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Equipment Layout

- Developed after the plot plant .
- Shows the equipment's arrangement , locations, spacing and maintenance spacing.

Equipment Layout

- Go to PDF

Piping General Arrangement /Layout

- The most important Drawing in for the piping engineer.
- Developed from the plot plan and Equipment layout, or directly from the 3D Model.
- Shows the pipes routing and supports locations, access platforms, etc .
- Shows also all the valves operation requirements.
- Fully developed piping GA shall provide full information for piping Fabrications.
- The piping GA used for piping erection.

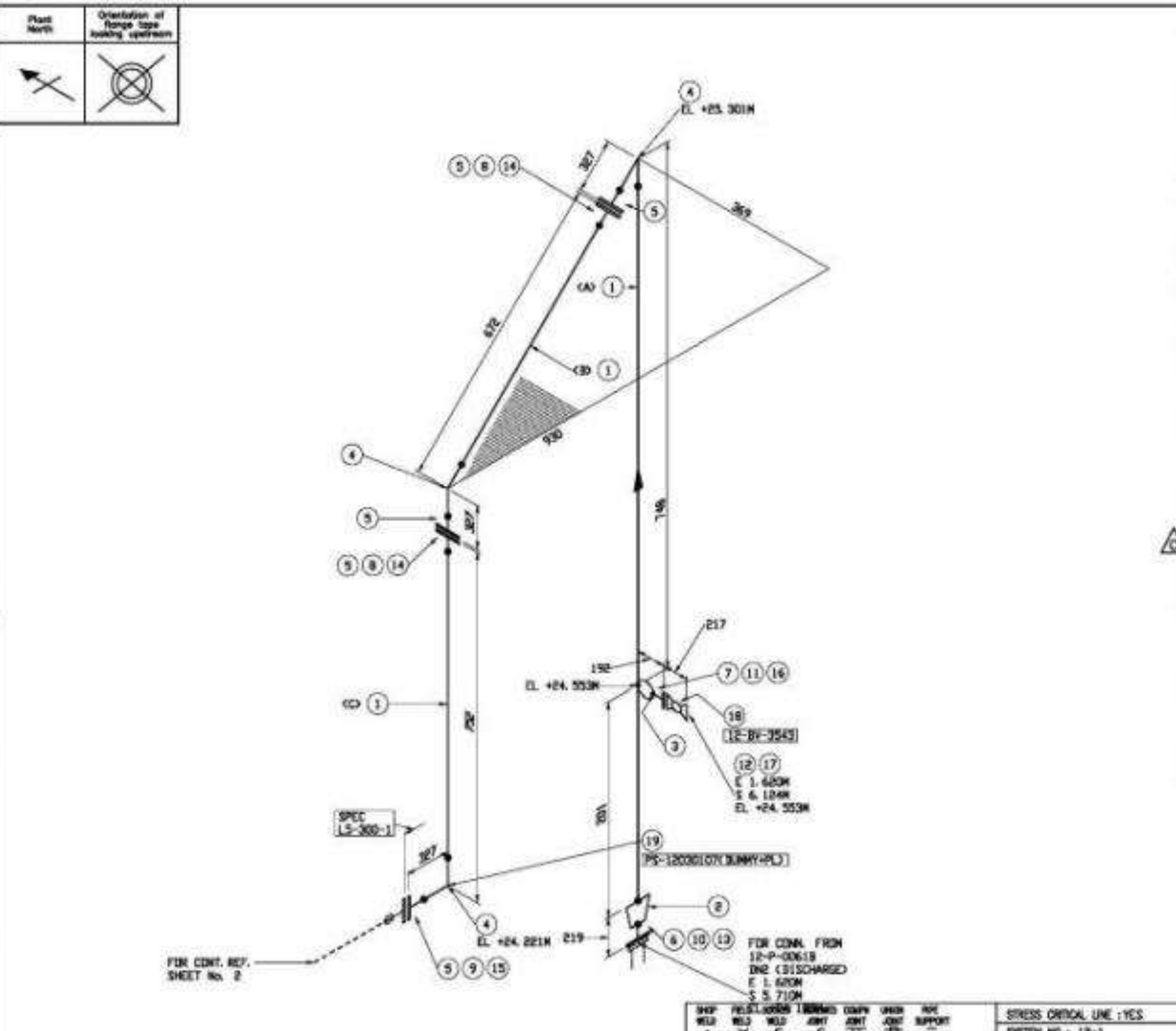
Piping General Arrangement /Layout

- Go to PDF

Piping Isometrics

- An isometric is a type of three-dimensional drawing known as a pictorial.
- Isometrics, or *Iso's* as they are commonly called, are developed using the three primary dimensions of an object: height, width, and depth.
- the isometric combines the three dimensions of the object into a single view to provide a pictorial representation.
- Includes all the material Call Out and the Material Take Off.
- Used for Fabrication Purposes, and some times for Erection.

Piping Isometrics



LIST OF MATERIAL

SR NO.	CLASS	SIZE	DESCRIPTION	QTY.
1	L5-300-1	6	PIPE-SCH. 40-BE-ASTM A106 Gr. B-ASME B36. 10-FBE COATED	1.5 M
2	L5-300-1	6X3	REDUCER CONC. -SCH. 40-BW-ASTM A234 Gr. WPB-ASME B16. 9-FBE COATED	1
3	L5-300-1	6X2	WELDOLET-SCH. XS-BE-ASTM A105N-MSS SP 97	1
4	L5-300-1	6	ELBOW-90°-LR-SCH. 40-BW-ASTM A234 Gr. WPB-ASME B16. 9-FBE COATED	3
5	L5-300-1	6	WELDNECK FLANGE-300#-SCH. 40-RF-ASTM A105N-ASME B16. 5-FBE COATED	5
6	L5-300-1	3	WELDNECK FLANGE-300#-SCH. 40-RF-ASTM A105N-ASME B16. 5-FBE COATED	1
7	L5-300-1	2	WELDNECK FLANGE-300#-SCH. 80-RF-ASTM A105N-ASME B16. 5-FBE COATED	1
8	L5-300-1	6	GASKET-300#-1.5MM THK. -COMPRESSED NON ASBESTOS FIBRE-OIL RESISTANT-FLAT RING-ASME B16.21	2
9	L5-300-1	6	INSULATION KIT-300#	1
10	L5-300-1	3	INSULATION KIT-300#	1
11	L5-300-1	2	GASKET-300#-1.5MM THK. -COMPRESSED NON ASBESTOS FIBRE-OIL RESISTANT-FLAT RING-ASME B16.21	1
12	L5-300-1	2	INSULATION KIT-300#	1
13	L5-300-1	3/4X115	STUD BOLTS WITH 2 HEAVY HEX NUTS-ASTM A193 Gr. B7/ASTM A194 Gr. 2H-ASME B18. 2.1/B18. 2.2-WITH SPIRAL WOUND ISOLATION SLEEVES (FOR INSULATION KIT-300#)	8
14	L5-300-1	3/4X120	STUD BOLTS WITH 2 HEAVY HEX NUTS-ASTM A193 Gr. B7/ASTM A194 Gr. 2H-ASME B18. 2.1/B18. 2.2	24
15	L5-300-1	3/4X125	STUD BOLTS WITH 2 HEAVY HEX NUTS-ASTM A193 Gr. B7/ASTM A194 Gr. 2H-ASME B18. 2.1/B18. 2.2 (FOR INSULATION KIT-300#)	12
16	L5-300-1	5/8X90	STUD BOLTS WITH 2 HEAVY HEX NUTS-ASTM A193 Gr. B7/ASTM A194 Gr. 2H-ASME B18. 2.1/B18. 2.2	8
17	L5-300-1	5/8X95	STUD BOLTS WITH 2 HEAVY HEX NUTS-ASTM A193 Gr. B7/ASTM A194 Gr. 2H-ASME B18. 2.1/B18. 2.2-WITH SPIRAL WOUND ISOLATION SLEEVES (FOR INSULATION KIT-300#)	8
18	L5-300-1	2	BALL VALVE FLANGED-REDUCED BORE-300#-RF-TRUNION MOUNTED BALL-LONG PATTERN-GLASS FILLED PTFE SEATS-ASTM A216 Gr. WCC/WCB+0.003" ENP COATING-TRIM SS316-API 6D-CODE BV-17	1
19	L5-300-1	6	PS-12030107(DUMMY+PL)	1

CUT PIPE LENGTH

PIECE NUM	LENGTH (MM)	SIZE (INCH)
(A)	720	6
(B)	345	6
(C)	424	6

Piping Bulk MTO

- List Type Document .
- Includes all the piping material (Non consumables) which shall be installed in the project.
- Includes Items Description, Quantity and special requirement for the items to be procured.
- Input to the procurement
- Done in stages:

A. 70% (In the beginning of the project)
B. 80% (After issuing 50% of the Iso's)
C. 90% (After issuing 100% of the Iso's)
D. 100%. (After issuing all the ISO's for Construction)

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Other Drawings and documents

- Stress Analysis Reports
- Piping Key Plans.
- Nozzle orientations

Piping Calculations

- Piping Wall Thickness Calculations .
- Pipe Supports Span Calculations

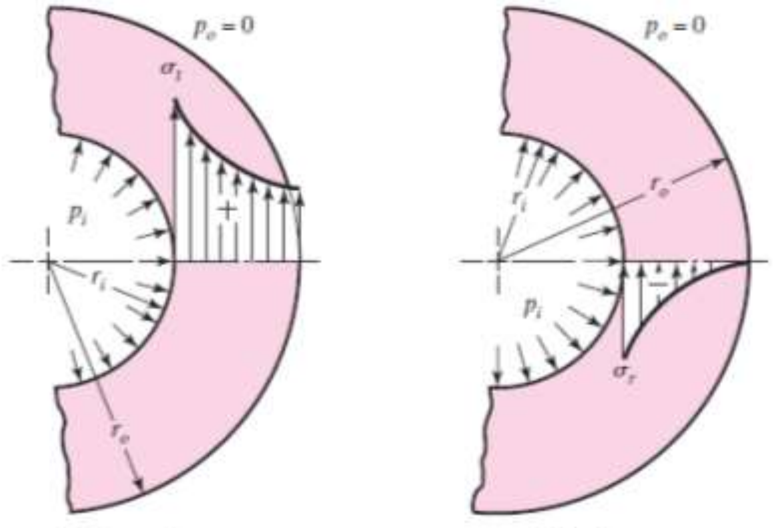
Pipe Wall Thickness Calculations

- Used to check the adequacy of pipe thickness for internal pressure.
- Uses the formula of Thin-Walled Vessels:

  $$S=PD/2t.$$

- D/T shall be always checked before use (D/T shall be <6)

Every code has some correction factors included



(a) Tangential stress distribution

(b) Radial stress distribution

TABLE 5.4 Required Thickness in Inches for Each Code

Code	Formula	Calculated t	Comment
B31.1	$t_m = \frac{PD_o}{2(SE + Py)} + A$	0.094	6 std = 0.245 min
B31.3	$t_m = \frac{PD_o}{2(SE + Py)} + A$	0.070	6 std = 0.245 min
B31.3 (chapter IX)	$t = \frac{D_o - 2c_o}{2}\left[1 - \exp\left(\frac{-1.155P}{S}\right)\right]$	0.080	See discussion for comments
B31.4	$t = \frac{PD_o}{2SE(0.72)}$	0.057	6 std = 0.245 min
B31.5	$t_m = \frac{PD_o}{2(S + Py)} + A$	0.094	6 std = 0.245 min
B31.8	$t = \frac{PD_o}{2SFET}$	0.082	6 std = 0.245 min
B31.9	$t = \frac{PD_o}{2SE} + A$	0.109	6 std = 0.245 min actual is A-106 B
B31.11	$t = \frac{PD_o}{2SE(0.80)}$	0.051	6 std = 0.245

In this table,

P = pressure
D_o = outside diameter
F = B31.8 design factor (used compressor station = 0.5)
T = temperature derating factor of 1
A = corrosion/mechanical factor

- As mentioned before , the pipe is beam , acting as pressure vessel .
- Since it is beam , beam formulas govern the stress calculations for supporting purpose.
- The pipe is neither simple supported beam , nor Fixed end , it is something in between.
- The following formulas governs the support span calculations.

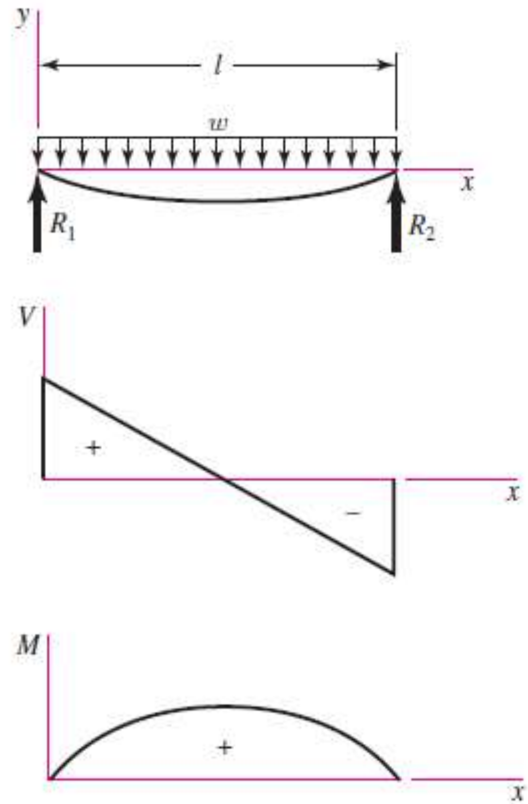
Pipe Support Span Calculations

Table A–9

Shear, Moment, and Deflection of Beams *(Continued)*

(*Note:* Force and moment reactions are positive in the directions shown; equations for shear force *V* and bending moment *M* follow the sign conventions given in Sec. 3–2.)

7 Simple supports—uniform load



$$R_1 = R_2 = \frac{wl}{2} \qquad V = \frac{wl}{2} - wx$$

$$M = \frac{wx}{2}(l - x)$$

$$y = \frac{wx}{24EI}(2lx^2 - x^3 - l^3)$$

$$y_{max} = -\frac{5wl^4}{384EI}$$

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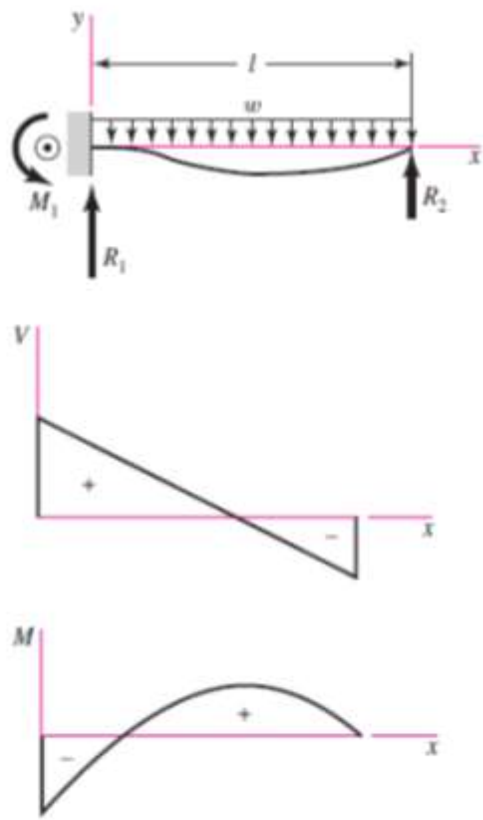
Pipe Support Span Calculations

Table A-9

Shear, Moment, and Deflection of Beams *(Continued)*
(*Note:* Force and moment reactions are positive in the directions shown; equations for shear force *V* and bending moment *M* follow the sign conventions given in Sec. 3–2.)

13 One fixed and one simple support—uniform load



$$R_1 = \frac{5wl}{8} \qquad R_2 = \frac{3wl}{8} \qquad M_1 = \frac{wl^2}{8}$$

$$V = \frac{5wl}{8} - wx$$

$$M = -\frac{w}{8}(4x^2 - 5lx + l^2)$$

$$y = \frac{wx^2}{48EI}(l - x)(2x - 3l)$$

Pipe Support Span Calculations

- 2 factors effects the span , the Mid Span Deflection and the Stresses .
- For stresses purposed , the governing formula is M/Z :

M : Bending Moment.

Z : Section Modulus (I/c) .

- Solving for simple supported beam will lead to the following formula :

$$M_A = \frac{wl^2}{12}$$

- The Longitudinal Stress due to pipe weight + Longitudinal Stress due to pressure shall be added together and the results shall be compared with the Allowable stress as per the design code , see example below

Pipe Support Span Calculations

$$l_{max} \leq \sqrt{\left(S_h - \frac{PD_o}{4t_n}\right)\frac{12}{w}\left(\frac{\pi\left(D^4 - (D-2t_n)^4\right)}{32D}\right)} \quad (4$$

Pipe Support Span Calculations

- For the mid span deflection (Sagging) , the beam deflection formulas can be used.

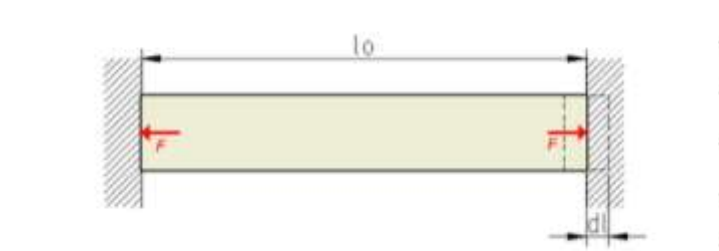
Piping Stress Analysis

- The process of calculation stresses on pipe , to ensure piping flexibility, structural integrity and to ensure system operability.
- The main purpose of stress analysis is to ensure that piping system has sufficient flexibility / rigidity to prevent any of the followings,:

A. Failure of piping from overstress or fatigue.
B. Leakage at joints (Especially the Flanged Joints).
C. Detrimental stress or distortion in piping or connected mechanical equipment such as Pig launcher/receiver, KO Drum and gas filters and metering skid, pumps, etc. resulting from excessive thrust and moments in piping.
D. Undesired displacement of the pipes.
E. Excessive loads and moments on connected equipment, anchor points, flanged connections, etc.

Pipe Stress

- If the pipe is free to move and expand, no stress will occur.
- In the moment we put restraints on the pipe, stress occur ->Thermal Strains Will convert to stresses .



- The stress can be simplified in the following formula:

Pipe Stress

- s = E a (DT)

Where

- s :Expansion Stress (N/mm2).
- E : Young Modulus (N/mm2).
- a : The Material coefficient of thermal expansion (mm/mm/ºC)
- DT : Temperature Difference (Installation to Design /Operating) (ºC)

Method of stress analysis

- Visual Method : For non critical lines .
- Approximate Method :Using Manual calculations.
- Formal computer stress analysis : Using Stress Analysis Program such as CAESAR II and AutoPIPE.

Stress Analysis Programs

- Many programs are available in the market for stress analysis.
- The most dominant programs are CAESAR II- from Intergraph , and Auto pipe from Bentley.
- The most used program which is widely acceptable program is CAESAR II.

How these programs works

- The programs deal with the pipe as a beam .
- After Modelling ,program calculates the stiffness of every element (K =F/Dx).
- The stiffness of the elements then inserted on the overall Stiffness matrix .
- By solving the stiffness matrix, the program to calculates element forces, moments and displacements, and convert it to stresses.

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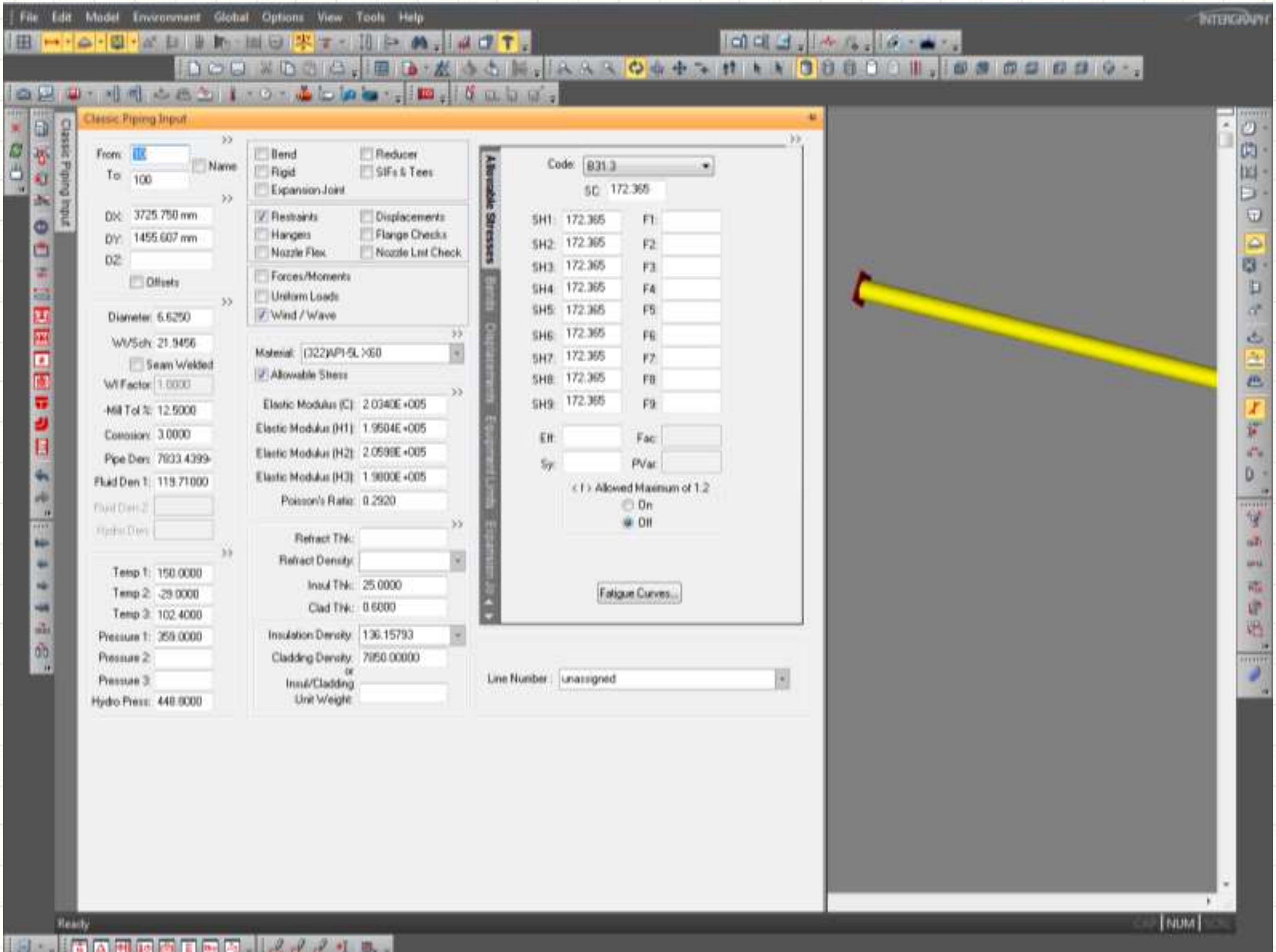
CAESAR II Input screen



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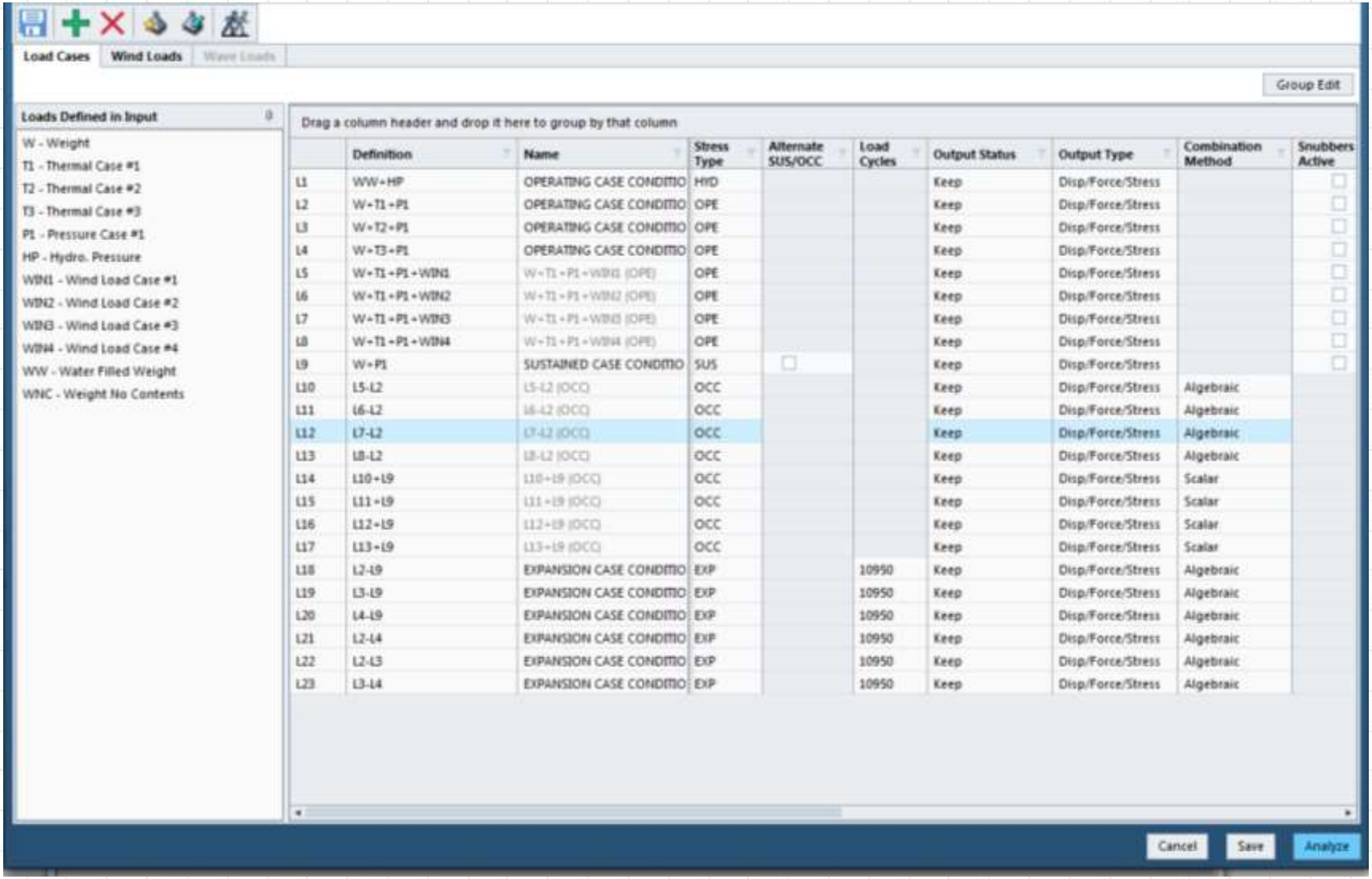
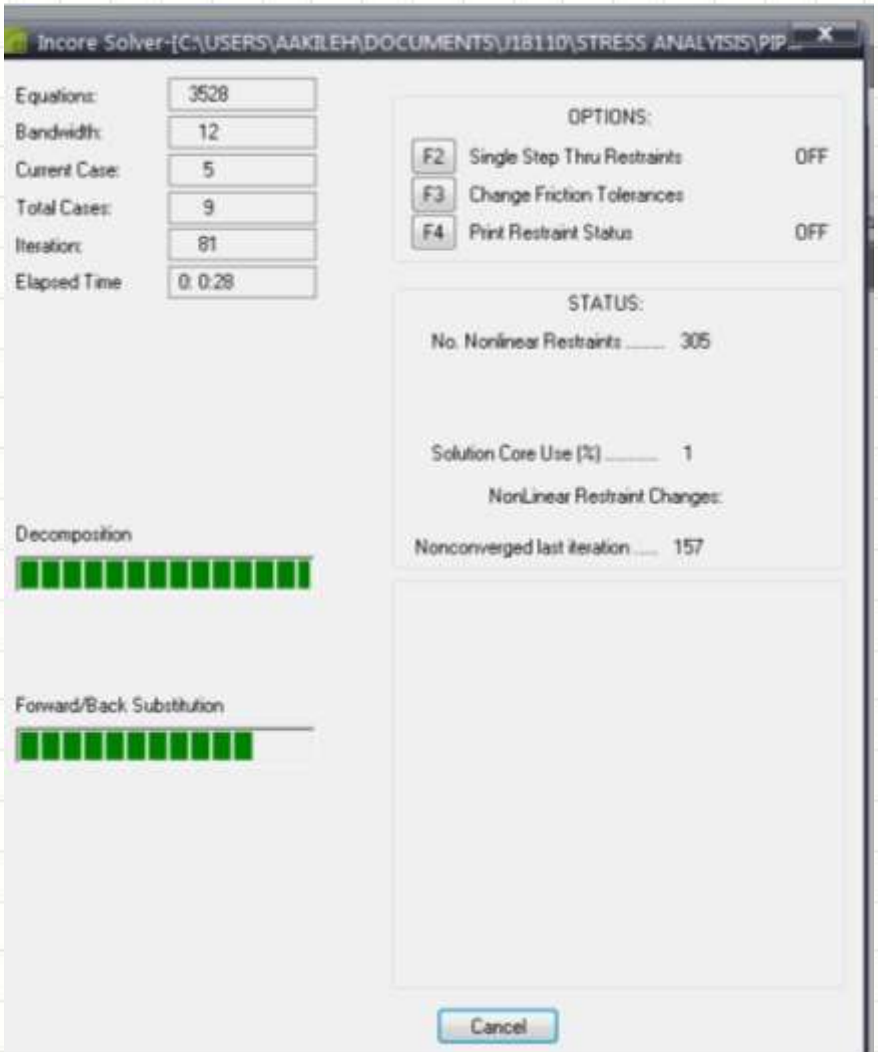
CAESAR II Load Cases Screen



	Definition	Name	Stress Type	Alternate SUS/OCC	Load Cycles	Output Status	Output Type	Combination Method	Snubbers Active
L1	WW+HP	OPERATING CASE CONDITIO	HYD			Keep	Disp/Force/Stress		☐
L2	W+T1+P1	OPERATING CASE CONDITIO	OPE			Keep	Disp/Force/Stress		☐
L3	W+T2+P1	OPERATING CASE CONDITIO	OPE			Keep	Disp/Force/Stress		☐
L4	W+T3+P1	OPERATING CASE CONDITIO	OPE			Keep	Disp/Force/Stress		☐
L5	W+T1+P1+WIN1	W+T1+P1+WIN1 (OPE)	OPE			Keep	Disp/Force/Stress		☐
L6	W+T1+P1+WIN2	W+T1+P1+WIN2 (OPE)	OPE			Keep	Disp/Force/Stress		☐
L7	W+T1+P1+WIN3	W+T1+P1+WIN3 (OPE)	OPE			Keep	Disp/Force/Stress		☐
L8	W+T1+P1+WIN4	W+T1+P1+WIN4 (OPE)	OPE			Keep	Disp/Force/Stress		☐
L9	W+P1	SUSTAINED CASE CONDITIO	SUS	☐		Keep	Disp/Force/Stress		☐
L10	L5-L2	L5-L2 (OCC)	OCC			Keep	Disp/Force/Stress	Algebraic	
L11	L6-L2	L6-L2 (OCC)	OCC			Keep	Disp/Force/Stress	Algebraic	
L12	L7-L2	L7-L2 (OCC)	OCC			Keep	Disp/Force/Stress	Algebraic	
L13	L8-L2	L8-L2 (OCC)	OCC			Keep	Disp/Force/Stress	Algebraic	
L14	L10+L9	L10+L9 (OCC)	OCC			Keep	Disp/Force/Stress	Scalar	
L15	L11+L9	L11+L9 (OCC)	OCC			Keep	Disp/Force/Stress	Scalar	
L16	L12+L9	L12+L9 (OCC)	OCC			Keep	Disp/Force/Stress	Scalar	
L17	L13+L9	L13+L9 (OCC)	OCC			Keep	Disp/Force/Stress	Scalar	
L18	L2-L9	EXPANSION CASE CONDITIO	EXP		10950	Keep	Disp/Force/Stress	Algebraic	
L19	L3-L9	EXPANSION CASE CONDITIO	EXP		10950	Keep	Disp/Force/Stress	Algebraic	
L20	L4-L9	EXPANSION CASE CONDITIO	EXP		10950	Keep	Disp/Force/Stress	Algebraic	
L21	L2-L4	EXPANSION CASE CONDITIO	EXP		10950	Keep	Disp/Force/Stress	Algebraic	
L22	L2-L3	EXPANSION CASE CONDITIO	EXP		10950	Keep	Disp/Force/Stress	Algebraic	
L23	L3-L4	EXPANSION CASE CONDITIO	EXP		10950	Keep	Disp/Force/Stress	Algebraic	

CAESAR II Iteration Screen



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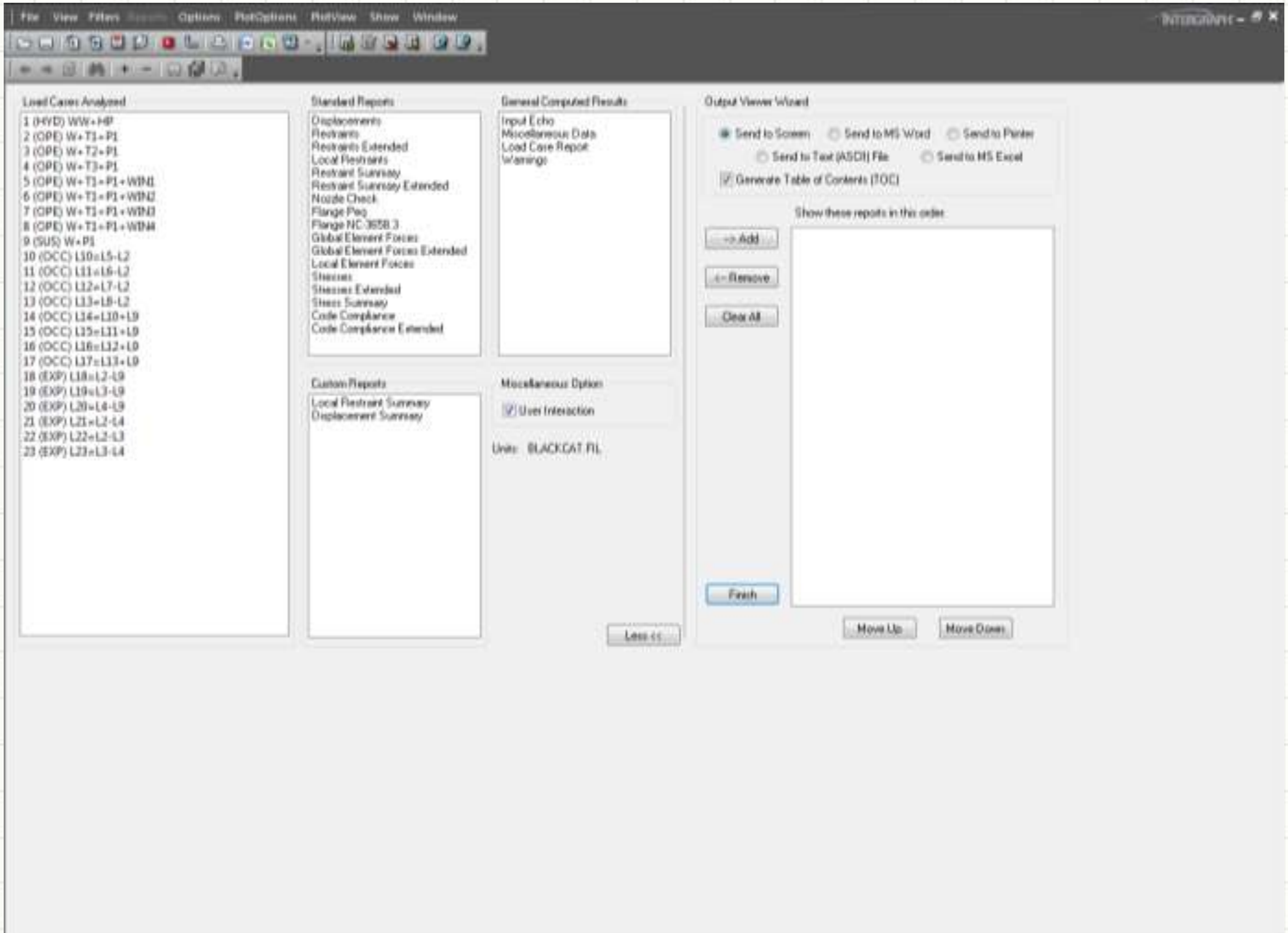
CAESAR II Output Screen



Difference between the programs (CAESAR II vs. Auto pipe)

CAESAR II	AutoPIPE
Less user Friendly	More User friendly
Comprehensive technical guide and technical reference guide	Less Comprehensive technical guide and technical reference guide
Has connectivity to CADWORX® and SP3D 3d modelling software's	Has connectivity to AutoPlant 3d modelling software
Different in combining the load cases	
Different in dealing with the non linear restraints	

Piping Testing Requirements

- Piping Design Engineer Decides the testing requirements of piping system based on the codes and standards.
- Testing requirements includes but not limited to :

A. Visual testing .
B. Non Destructive Test : Extents and percentage of radiography of welds, Extent and percentage of MPI/LPT of welds.
C. Leak test of the piping system : Service Test/ Hydrostatic test /Pneumatic Test /Sensitive leak test.

Hydrostat Pressure/Leak test

- Used to check the system integrity ,and the leakage which may occur on the joints.
- Water is used as testing medium , some times other medium are used .
- As per ASME B31.3 , systems shall be pressurized to 1.5 Design pressure.
- For the piping system dealing with gasses , additional temporary supports may need to be considered.
- Holding Time depends on the time the inspector needs to check all the joints (Minimum 10 Minutes for ASME B31.3 and B31.1).

Pneumatic Pressure/Leak test

- Used to check the system integrity ,and the leakage which may occur on the joints.
- Air , Nitrogen , Argon , Helium are used as testing media.
- Usually used for small bore piping system.
- More safety consideration shall be taken for such test .

- Thank You